Nantucket Harbor Transects
2003

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Temperature and dissolved oxygen transects have been conducted in Nantucket Harbor for the years ’01, and ‘02 in order to approximate warming and cooling trends related to scallop reproduction and development. During the year ’03 transects were abbreviated to harbor sampling events, daily recordings of temperature at the Boat House during the summer, and random samplings during other evolutions throughout the harbor. This was due in large part to time constraints involving other Marine Department projects including but not limited to the MA. Estuaries Project in Madaket. Though the data sets are limited and less comprehensive than previous years it is believed that they should be sufficient to make the accurate determinations sought after for this report. This is in part due to the information and conclusions drawn from previous years. Generally the harbor is believed to be well-mixed and relatively isothermic, with subtle variations between the head and the foot of the harbor. The head of the harbor warms quicker in the summer and cools faster in the fall, as it is a smaller water body than the sound with decreased circulation.

Spawning and feeding are temperature dependent physiological processes of the scallop. Dissolved oxygen is also an important factor in determining the location of scallop populations; based on the level of oxygen content they need in the water in order to survive. By monitoring these two factors throughout the harbor it is possible to determine when and where scallops have spawned, when they will begin to feed, i.e. mature, and when they will fall into a period of cessation i.e. stop growing. This data there fore will give us a better understanding of the scallop’s life cycle.

Three transects were established across the harbor running north to south in each basin, with three sampling points along each line (Map #1). These transects and points were picked to provide information about bottom characteristics throughout the harbor. They include shallow (3-6’), mid (10-13’), and deep (22-25’) bottom points. These points were sampled from the Harbormaster’s boat using a Garmin GPS positioning system, and a Raytheon depth finder while referencing (Map #1). A YSI 85 meter with a 30’ cord and weighted probe was used to record temperature and dissolved oxygen at bottom depths at these points. It has been determined that the deep-water points have too little light penetration, and too little dissolved oxygen to support the life processes of the scallop year round. These points may be monitored from time to time, but are no longer considered critical for this study.

The information gathered was compiled, calculated and translated on to three charts (1, 2, and 3). These points represent transects 1,2.5, and 5, and are believed to be sufficient because the harbor is for the most part isothermic. This means that there is good mixing of temperature throughout the water column throughout the harbor. There are subtle variations in these three tansects that enable us to determine approximately when spawning events took place in different parts of the harbor. Hypoxic and anoxic levels relating to suitable habitat can also be approximated at specific times and locations. Further optimal feeding periods relating to growth and gonadal development and adversely lengths of cessation can be determined from these charts.

Analysis of this data and interpretation of these graphs show some general trends and a few detailed events throughout the year. Though there is very little stratification there are differences between shallow, mid, and deep-water areas. In general mid and deep-water areas tend to be colder with lower dissolved oxygen levels. Another general trend involves the circulation of the harbor; where by the water in the head of the harbor

(Wauwinet) is exchanged at a slower rate than that at the opening (Channel). This was also shown in the Nantucket Harbor Circulation Computer Model provided by ASA (Applied Science Associates). The transects and previous harbor studies reflect this pattern of circulation. It can be surmised from this trend that spawning is initiated in the shallow water in the head of the harbor. However temperatures are so similar, that spawning probably occurs throughout the harbor at roughly the same time.

Specific details of this analysis show that spawning occurred in late June, around the 6/27* sampling date. Spawning was induced when temperatures first peaked through the 20° C mark in shallow depths (4') of water at the head of the harbor, chart (3). This spring set was soon followed by a spawning in the mid harbor areas, chart (2). Last to spawn were the scallops in and around the foot of the harbor late June; this area covered roughly the Horse Shed, First Point, Hussey Shoal, Monomoy Piers, and The Mooring Field, transect (5). This analysis is congruent with (Sastry, 1963) that mature scallops are induced to spawn by temperatures rapidly rising or falling between 17 and 22° C. Temperature data shows that during mid August temperatures peaked as high as 24.8° C, raising temperatures throughout the harbor to nearly 77° F. Such extremes would not only lead to anoxic events, but would also be extremely stressful on the older scallops. Fortunately these elevated temperatures did not last long this year. This peak however, may have induced a mid summer spawning of mature adults that were waiting for temperatures to fall (Sastry, 1966). This mid summer set would also account for the variation in seed size found in the first collection of spat bags, where the seed showed two distinct size averages (5-10) and (20-30) mm, when sorted. The fall set is believed to have occurred as late as 9/29 as shown on the lower harbor temperature graph, and on all the charts where temperatures began to fall throughout the harbor and in the sound with the onset of fall.

Hypoxic dissolved oxygen levels were recorded at the deep transect points in Quaise (2.52), and at the head of the harbor (1.3) during the September harbor sampling event. The mid level depths throughout the harbor also showed hypoxic conditions on 9/29 where near transect (5) the d.o. was recorded at 4.92 mg/l. Hypoxic conditions are an indication of eutrophic conditions, and would indicate areas where scallops would not be able to survive. This level of eutrophication shows a decrease in scallop habitat in the harbor during the month of September. These conditions are directly related to water temperature, and were less severe for '03 than '02.

When temperatures rise above 7° C, metabolic processes like feeding and digestion begin within the scallop (Sastry, 1968). The graphs show that these temperatures had been attained by late March, from the 3/25, and 3/28 sampling events. Temperatures did not fall below 7° C until approximately the 11/25 sampling event. It is believed that water temperature did not decrease until early December, which would have resulted in an eight-month feeding, and growth period. Conversely it may be estimated that for four months there would have been a period of cessation. This period of cessation in the scallop's metabolic processes results in a well defined raised annual growth line on the scallop's shell and is used as the determining factor in the judgment between juveniles and adults (Belding, 1910).

This data shows that the spawning period was longer by one month, and the feeding period was shorter by one month for this '03 cycle. This means that scallops in '03 were less active with more time to spawn than scallops in '02, assuming that warming and cooling trends last approximately the same amount of time each year. The comparison comes from the first year temperature transects were recorded and analyzed, (Conant, 2001). The decreased activity and cooler temperatures would allow for a decrease in the duration and level of stress on the shellfish, and may account for better health and survivorship of the scallops for the ’03-’04 fishing season. The scallops obviously most affected by this would be the older ones, the second year classic adults (two growth rings high on the shell), and the third year nub adults (two growth rings, one low, one high on the shell).

Extreme cold events are also of importance, because they can result directly in the mortality of scallops. Salt water freezes at 28° F, and scallops in shallow water may be crushed or smothered, or otherwise affected to some degree as to result in their eventual death. An icing of the harbor occurred during both ’02-’03, and ’03-’04 fishing seasons and lasted for approximately one month. This icing would have contributed to the premature death of juveniles and adults in and around the shallow areas of the harbor. Also a strong Nor’easter (11/15/03) washed up thousands of seed scallops in the head of the harbor, though they were retuned to the water the majority (80%) is expected to die from gill damage, and exposure.

Trends observed were that the head of the harbor warms and cools faster than the rest of the harbor as a result of circulation patterns, i.e. water being trapped there for longer periods of time. Also temperature is inversely proportional to depth and dissolved oxygen, and results in hypoxia and anoxia in certain parts of the harbor at certain times of the year. There were three distinct changes in temperature in the harbor, which may have resulted in three different spawning events. These dates can be closely approximated, and are thought to be 6/27, 8/15, and 9/29. Cold-water temperatures in the harbor would have resulted in four months of cessation for the scallop population, with an activity period of eight months. The temperature changes also help to determine how old scallops would be, based upon when they were spawned, the resultant height of the growth ring, and their level of sexual maturity. Age is shown by the location of the growth ring, or rings on the shell and the coloration of the gonad before and after the last spawning event. Transects and temperature data will continue to be collected in 2004 in order to note continuing trends or yearly changes.

Harbor Transect 2003

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1.1 Shallow

	30-May	6-Jun	11-Jul	3-Sep
depth	4	4	4	4
temp	15.2	23.9	23.4	20.6
d.o.	8.58	7.41	6.45	6.95

1.3 Deep

	30-May	6-Jun	11-Jul	3-Sep
depth	27	24	19	20
temp	14.5	23.1	23.2	20.7
d.o.	5.68	7.09	5.23	5.97

1.5 Mid

	30-May	6-Jun	11-Jul	3-Sep
depth	9	8.4	10	10
temp	14.9	23.4	22.1	20.5
d.o.	8.74	7.68	6.43	6.86

2.51 Mid

	30-May	6-Jun	11-Jul	3-Sep
depth	9	9.6	12	11
temp	14.6	23.3	21.9	19.8
d.o.	8.49	8.18	6.09	7.07

2.52 Deep

	30-May	6-Jun	11-Jul	3-Sep
depth	30	21.5	21	21
temp	14.3	21.7	20.8	20.4
d.o.	5.47	7.66	6.78	4.97

2.53 Shallow

	30-May	6-Jun	11-Jul	3-Sep
depth	5	5	5	5
temp	15.2	23.8	21.8	21.1
d.o.	8.88	9.15	7.42	9.63

5.2 Deep

	30-May	6-Jun	11-Jul	3-Sep
depth	27	19.5	24	23
temp	13.2	19.2	20.7	20.5
d.o.	9.21	8.23	6.44	7.74

5.4 Shallow

	30-May	6-Jun	11-Jul	3-Sep
depth	6	4.6	6	6
temp	13.8	20.3	20.6	20.8
d.o.	9.2	8.79	7.41	7.56

Harbor Transect 2004

1.1 Shallow

	29-Jun
depth	3
temp	21.7
d.o.	6.93

1.3 Deep

	29-Jun
depth	24
temp	21.8
d.o.	5

1.5 Mid

	29-Jun
depth	10
temp	21.4
d.o.	6.37

2.51 Mid

	29-Jun
depth	9
temp	21.4
d.o.	6.83

2.52 Deep

	29-Jun
depth	21
temp	21
d.o.	6.8

2.53 Shallow

	29-Jun
depth	3
temp	21.2
d.o.	7.8

5.2 Deep

	29-Jun
depth	20
temp	19.7
d.o.	7.12

5.4 Shallow

	29-Jun
depth	5
temp	19.7
d.o.	7.54

5.6 Mid				
	30-May	6-Jun	11-Jul	3-Sep
depth	12	11.7	9	10
temp	14.5	20.7	20.6	20.5
d.o.	8.72	8.11	7.17	7.41

5.6 Mid
29-Jun
12
20
7.42